22156 D3

(12) UK Patent Application (19) GB (11) 2 019 369 A

(21) Application No 7913401
(22) Date of filing 18 Apr 1979
(23) Claims filed 18 Apr 1979
(30) Priority data
(31) 15689/78
(32) 20 Apr 1978
(33) United Kingdom (GB)
(43) Application published 31 Oct 1979
(51) INT CL² C01F 7/44
(52) Domestic classification C1A 421 423 425 N4 PF9B
(56) Documents cited GB 745552
(58) Field of search C1A
(71) Applicants
F. L. Smidth & Co. A/S.
77, Vigerslev Alle,
DK-2500 Valby,
Copenhagen, Denmark.
(72) Inventor
Benny Erik Raahauge
(74) Agents
Gill Jennings & Every

(54) **Improvements relating to the production of anhydrous alumina**

(57) A method of and apparatus for producing anhydrous alumina from alumina trihydrate are disclosed in which free and chemically bound water is at least partially removed in a precalcining zone. For example, the alumina trihydrate (from 6) is suspended in and heated by a stream of hot gases from cyclone (2), separated in (1), suspended in and heated by hot gases from (3), and separated in (2), whereafter the precalcined dehydrated alumina is recrystallized at least partially to α-alumina in a reaction chamber (4) provided with means (7,8) for feeding fuel and oxygen containing gas to a combustion zone in the chamber (4). The exothermal recrystallization is initiated in the chamber (4) by further heating the precalcined alumina by suspending the material in hot combustion gases by intimate mixing of the precalcined alumina and fuel followed by suspension of this mixture in the oxygen containing gas fed to the combustion zone. The at least partially recrystallized alumina is then carried out of the reaction chamber (4) suspended in the combustion gas stream, separated from the gas stream in a particle/gas separator (3) and subjected to rapid cooling in a cooling zone (5).

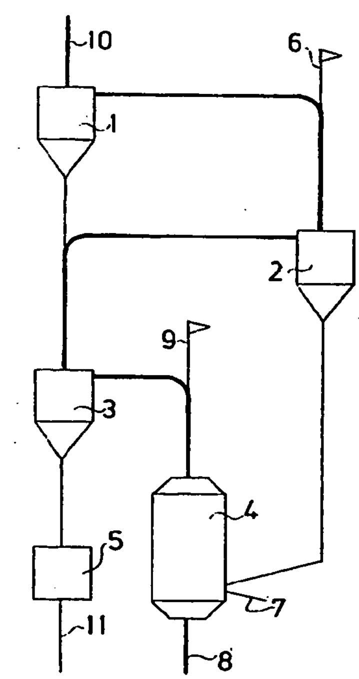

Fig 1

2019369

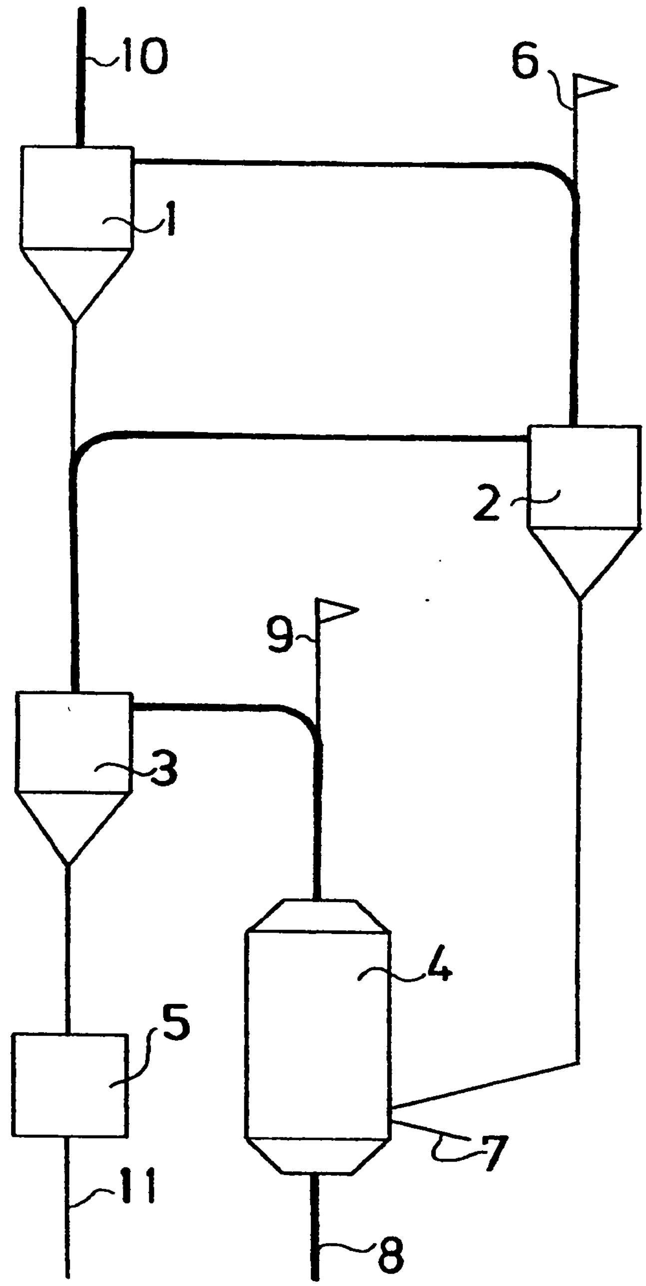

Fig 1

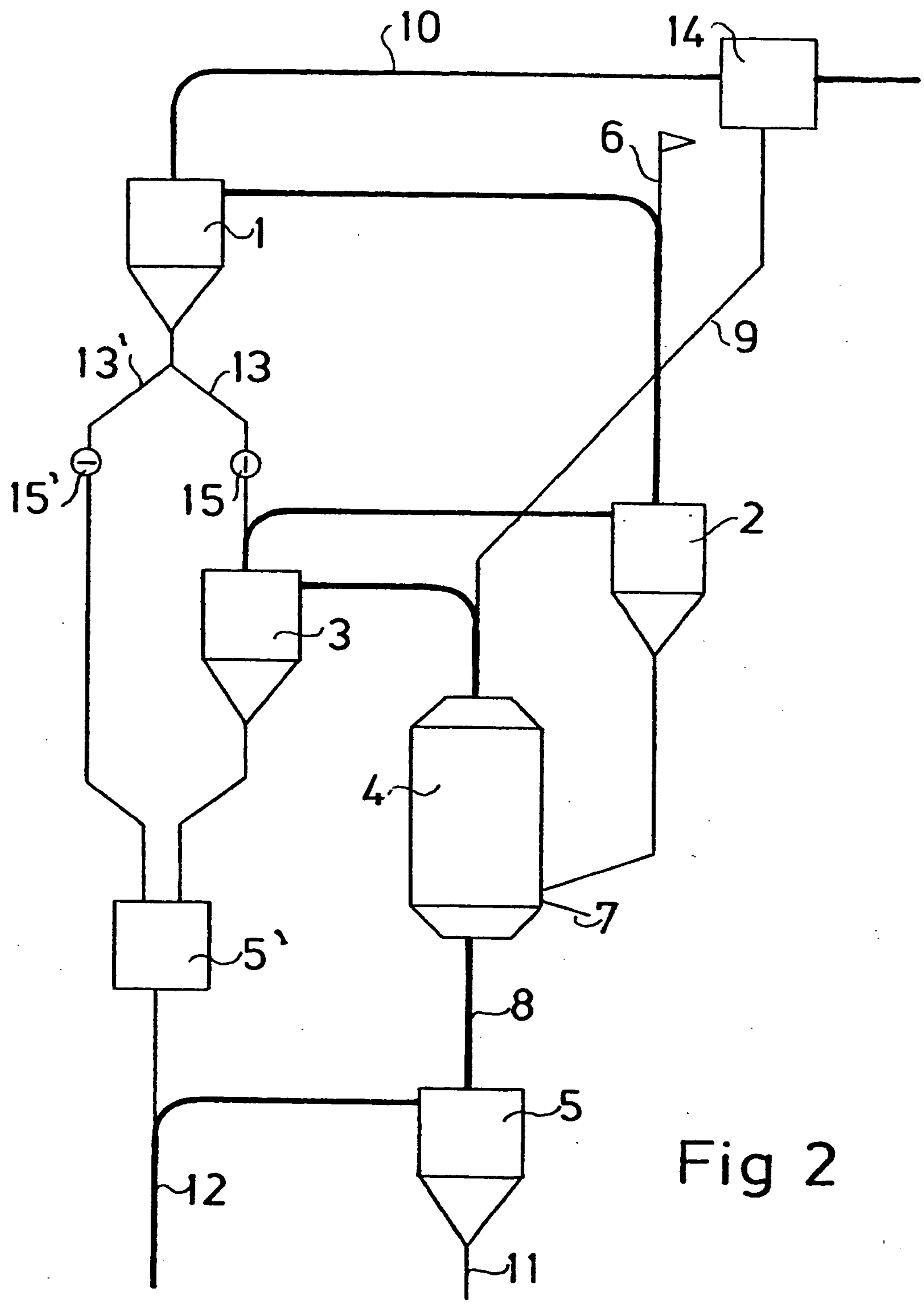

Fig 2

SPECIFICATION

Improvements relating to the production of anhydrous alumina

The present invention relates to production of alumina from alumina trihydrate. The manufacture of alumina, containing from 10 to 80 per cent α-Al_2O_3, from wet alumintrihydrate, having the general formula Al_2O_3, $3H_2O$ is a well known process in which the pulverous material exhibits both endothermal (dryness and calcination) and exothermal (formation of α-Al_2O_3) behaviour during the processing.

In the production of α-alumina, three distinct processes take place:

i) Evaporation of free moisture from the wet alumina trihydrate filter cake at about 100-110°C.

ii) Removal of the main part of water crystallization through calcination at about 250-1000°C and simultaneous recrystallization into various intermediate aluminium hydroxide compounds.

iii) Exothermal formation of α-Al_2O_3, starting very slowly at about 1000°C.

While the processes i) and ii) require the addition of heat in order to proceed, the third process requires no heat addition when initiated at about 1000°C, except for what is needed to counterbalance external losses. However, the rate of formation of α-Al_2O_3 increases rapidly with increasing temperatures and, consequently, the time needed for reaching desired contents of α-Al_2O_3 decreases when the temperature is increased above 1000°C.

Methods are known in which the material is subjected to heat treatment in separate process units.

Thus German OS 1,184,744 describes calcining of aluminium hydroxide and formation of α-Al_2O_3 in two separate process units operating at different temperatures.

The calcining is conducted in the riser pipe to the fourth cyclone in a conventional cyclone preheater by direct combustion of fuel from a burner placed in the bottom of the riser pipe.

The formation of α-Al_2O_3 is carried out in a stationary adiabatic vessel where the material flows by gravity, or alternatively, in a rotary kiln equipped with a burner from which hot smoke gases travel countercurrently to the material discharged from the cyclone preheater into the kiln.

German OS 1,207,361 describes a process utilizing a fluid-bed, in which the formation of α-Al_2O_3 takes place after being fed from a cyclone preheater. The material from the cyclone preheater is injected into the bed through a flame burning tangentially at the top of the fluid-bed reactor. By this method of heat treatment the temperature of the material reaches a level so that the formation of α-Al_2O_3 is initiated.

In French Patent Specification 1,540,679 a method is described which combines the conventional cyclone preheater with a swirl chamber to initiate the formation of α-Al_2O_3 before discharging the 1200-1400°C hot material to a rotary kiln or fluid-bed.

The characteristic feature of the swirl chamber is that burner and feed pipe for the material are placed vertically at the top of the chamber, whereas secondary air is admitted tangentially in the bottom of the conic section, causing induction of the swirl.

A commercial process in operation today utilizes the principles of a fast fluidized-bed, also named the expanded fluidized-bed, disclosed in German Patent Specifications 1,092,889 and 1,146,041.

In this process, dry and precalcined alumina is fed to a fluid-bed kiln in which the main part of the solid circulates via an externally controlled recirculation arrangement.

The oldest commercial stationary process, i.e. process not using a rotary kiln, for making alumina is the flud-flash calcination process which is described in Engineering and Mining Journal, April 1974, page 23.

In this process, the formation of α-Al_2O_3 is initiated in a combustion reactor. Fuel and air are burnt at the bottom of the furnace where the burners are mounted on the outer circumference of the combustion chamber. Precalcined alumina is fed above the combustion zone and carried out with the hot smoke gases through the top of the furnace. The hot material is separated from the smoke gases at the top of a fluid-bed vessel acting as a cyclone separator, and discharged to the bottom thereof where the fluid-bed is established.

All the above-mentioned patents specifications and commercial processes relate to the carrying out of the drying and precalcining processes in cyclone preheaters of various modifications, and they all carry out the formation of α-Al_2O_3 in either a fluid-bed, a rotary kiln, or an adiabatic vessel. The common features of these units are that the holding time of the material falls within a range from several minutes to more than 2 hours at a temperature level ranging from 1100 to 1200°C.

Compared with stationary plants, commercial processes using rotary kilns have the serious drawback of a substantially higher specific heat consumption.

Stationary plants utilizing the fluid-bed principles, including the expanded type, are complicated to operate and maintenance cost is relatively high.

Plants using fluidized beds are complicated to operate because less air than necessary for the combustion of the fuel is needed in order to fluidize the material, with resultant complicated air flows which must be carefully controlled.

In addition, fluidized bed operation requires the presence of a fragile gas distribution device in order to establish a proper fluidization, which again necessitates special precautions in order to encure undisturbed operation.

Japanese patent publication No. 12 11 98/75 describes a method of calcining sandy aluminium hydroxide in which aluminium hydroxide is converted into anhydrous alumina in a cyclone preheater whereafter the precalcined alumina is subjected to α conversion at a temperature of 1150-1450°C in a gas flow calciner. However, it is emphasized in the Japanese publication that the preheating must comprise a rise of temperature of the material to 600-1100°C, which must take place in less than 30 seconds, in order to obtain a reasonable rate of α

conversion and that the flow rate of the material should be kept below 12m/second, in order to avoid particle break down.

This method suffers from several drawbacks: The high temperature requirements of the material entering the final heat treatment raises the temperature of the gases leaving the cyclone preheater with resultant rather poor heat economy. Further, the low particle velocity requires relatively large pipes in the precalcining zone, and thus relatively large investment costs and a comparatively poor heat economy.

The object of the present invention is to provide an improved method of and a simplified apparatus for heat treating finely divided material, especially suited for the production of alumina.

The process and apparatus of the present invention surmount the aforesaid drawbacks as it has been found possible to create very high temperatures in a combustion zone of a reaction chamber, allowing a drastic reduction of the recrystallization time from at least several minutes to some seconds without the above mentioned uneconomic limitations of particle velocity and demands for a high temperature of the preclacined material.

The present invention therefore provides a method of producing alumina from alumina trihydrate in which free and chemically bound water is at least partially removed in a precalcining zone wherein the alumina trihydrate is suspended in and heated by and separated from a stream of hot gases, whereafter the precalcined dehydrated alumina is recrystallized at least partially to α-alumina in a reaction chamber provided with means for feeding fuel and oxygen containing gas to a combustion zone in the chamber, in which the exothermal recrystallization is initiated by further heating the precalcined alumina by suspending the material in hot combustion gases; whereafter the at least partially recrystallized alumina is carried out of the reaction chamber suspended in the combustion gas stream, separated from the gas stream and subjected to rapid cooling in a cooling zone characterized by providing a vigorous initiation of the recrystallization reaction by intimate mixing of precalcined alumina and fuel followed by suspension of this mixture in the oxygen containing gas fed to the combustion zone.

In this manner formation of α-Al_2O_3 from pulverous dry and precalcined alumina may be carried out in between 0.5 and 5 seconds at operating temperatures ranging from 1300 to 1600°C dependant on the desired content of α-Al_2O_3 in the product.

In one suitable way of carrying out the method, the oxygen containing gas is passed upwards through the centre of the bottom of the reaction chamber, the intimate mixing of precalcined alumina and fuel is established by introducing precalcined alumina and fuel at the bottom of the reaction chamber in mutually intersecting directions, and the at least partially recrystallized alumina and the exit gases from the combustion zone are carried out at the top of the reaction chamber by the gas stream.

The precalcined alumina may be fed onto a downwardly and inwardly inclined annular bottom wall of the reaction chamber. The fuel is preferably supplied at a lower position in the reaction chamber than the precalcined material, especially upwards through the bottom wall.

The gas stream from the reaction chamber relieved of the suspended alumina may be used as hot gas for drying and precalcining the material in the precalcined zone.

Improved heat economy is achieved if fine dust is separated from the exit gas from the precalcined zone and the fine dust is introduced into the suspension of material in the exit gases from the reaction chamber after the suspension has left the reaction chamber.

The precalcining is preferably carried out in a multi-stage cyclone preheater.

The material separated from the gas stream coming from the reaction chamber may be cooled by suspension in cooling air, separated from that air and the used cooling air introduced into the reaction chamber as oxygen containing air.

When the precalcining is carried out in a multistage cyclone preheater, the material coming from the uppermost cyclone may be divided into two material streams, the first material stream being directed to the riser pipe to the second cylone from the top, the second material stream and the material separated from the gas stream coming from the reaction chamber being suspended in cooling air, whereafter the material is separated from the air and subjected to further cooling, and the air is introduced into the reaction chamber as oxygen containing gas. The second material stream and the material separated from the gas stream coming from the reaction chamber may then be introduced into a mixing chamber and mixed before they are suspended in the cooling air.

The present invention also includes apparatus for producing anhydrous alumina by the above described method the apparatus comprising a multi-cyclone precalciner connected to a tubular reaction chamber having an upright axis provided with a central gas inlet in the bottom of the chamber and a central gas outlet in the top of the chamber leading to a particle/gas separator and ducts for introducing alumina from the precalciner and fuel into the chamber, and a cooler for the alumina separated in the particle/gas separator, characterized in that the reaction chamber is provided with a downwardly and inwardly inclined annular bottom wall, and that the ducts for introducing precalcined alumina and fuel are situated at the bottom of the chamber such that precalcined alumina and fuel enter into the chamber in intersecting paths.

The fuel duct is preferably situated below the duct for the precalcined material, particularly in the bottom wall.

The apparatus may comprise an exit gas pipe from the precalciner provided with an electrostatic filter and means for introducing filter dust from the filter into the riser pipe from the reaction chamber.

The material outlet from the uppermost cyclone may be provided with means for dividing the material stream into two material streams the first material stream being directed via a duct to the riser pipe to the second cyclone from the top, and the second

material stream and the material separated in the particle/gas separator being directed via ducts to a cooling air pipe in which the material is suspended whereby the outlet end of the air suspension pipe is connected to a separator having an outlet for the separated material and an outlet for air connected to the central gas inlet in the bottom of the reaction chamber.

A mixing chamber may then be connected to the outlet end of the ducts for the second material stream and the material separated from the gas stream coming from the reaction chamber, the mixing chamber having an outlet duct with an outlet in the cooling air pipe.

It is found that the high thermal efficiency of the combustion zone, enabling such vigorous initiation of the exothermal process that processes which according to the known art either lasted at least 30 minutes or necessitated a very high temperature of the material subjected to the final α conversion treatment now can be terminated in seconds without preheating to high temperatures, is due to the intimate contact between fuel, preheated material and oxygen containing gas which is characteristic of the present method and apparatus. This combustion principle is described in British Patent Specifications 1,428,680 and 1,463,124, but only in connection with endothermal processes which can be carried out practically isothermally. However, the application of this principle for heating of exothermal processes is novel, and the strong initiation effect is very surprising, especially considering the fact that the temperature of the precalcined material introduced into the reaction chamber is more than 100°C below the temperature of the precalcined material used in known processes.

Compared with systems employing a rotary kiln, the proposed stationary systems has the advantage of a much lower specific heat consumption, in the case of alumina calcining 750-800 kcal per kg compared with 1000-1100 kcal per kg for a rotary kiln system.

Compared with known stationary systems employing either conventional or expanded fluid-bed techniques, the present invention avoids the need for any kind of gas distributors placed in the gas/air flow path as well as any division of gas/air streams due to differences in air/gas requirements for combustion and fluidization, respectively.

No gas distribution devices are needed in order to obtain proper pneumatic conveying of the pulverous material through the high temperature reaction chamber, and the entire amount of combustion gas or preheated air needed for combustion is taken through the reaction chamber, avoiding splitting up of the gas flows involved.

Compared with other systems, very high temperatures are brought about by combustion of fuel in very hot preheated air, separated from any material requiring large amounts of heat supply in order to be heated up to the reaction temperature demanded. The holding time needed by the hot material in order to reach the desired chemical conversion is reduced substantially because of the high temperature level reached.

Compared with the method disclosed in the abovementioned Japanese patent publication the present invention avoids the drawback of requiring large diameter pipes to ensure a particle velocity below 12 m/seconds, and of requiring a high temperature of about 900°C for the material entering the α conversion zone as exemplified in example 1 in the Japanese publication, and still fulfills the requirements of very fast α conversion and insignificant particle breakdown.

Further improvements in the heat economy are achieved by means of the above-mentioned dust circulation and/or the partitioning of the solid material coming from the uppermost cyclone.

By using the dust cycle, i.e. returning the dust precipated from the gas leaving the uppermost cyclone in an electrostatic precipitator to the riser pipe from the reaction chamber, the cold dust is heated by heat exchange with the material and gas issuing from th reaction chamber and separated from the main pai. of the material in cyclone No. 3, thereby the temperature load on cyclone No. 3 is decreased, and the heat taken up by the fine dust from the electrostatic precipitator is carried back to the cyclone preheater together with the heat content reducing the amount of heat leaving with the main part of the material which is discharged into the cooler. The net effect obtained from this arrangement is that the heat load on the cooler is reduced while at the same time more heat is returned to the cyclone preheater where it is needed in order to precalcine the aluminium trihydrate.

Partitioning of the relatively cold material coming from the uppermost cyclone, and mixing of a part of it with the very hot material separated from the gas stream coming from the reaction chamber yield a further improvement in heat economy because of the direct heat exchange between the cold and hot material as opposed to the indirect heat transfer by the gaseous medium. Further, this arrangement make it possible to vary the properties of the final product.

Some examples in accordance with the present invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:–

Figure 1 is a diagram of one apparatus; and,

Figure 2 is a diagram of another apparatus.

Referring to Figure 1, a reaction chamber 4 defines a reaction zone for the recrystallization process, cyclones 1 and 2 a precalcining zone, cyclone 3 a separator for separating the product from the hot gases exiting from the reaction chamber, and a cooler 5 a cooling zone. Alumina trihydrate is introduced into the precalcining zone through an inlet 6 into the riser pipe from the second cyclone from the top. Dust from an electrostatic filter (not shown) can be introduced into the riser pipe from the reaction chamber through an inlet 9. The product separated from the hot gases in the cyclone 3 is cooled in the cooler 5 and discharged through an outlet 11. The reaction chamber is fed with fuel through a duct 7 and with oxygen containing gas through an inlet 8. The gases leave the preheating zone through a pipe 10, and are further dedusted in an electrostatic filter

(not shown).

The wet alumina trihydrate is introduced through the inlet 6 dried and precalcined in the stream of hot gases in the riser pipe from the second cyclone from the top, separated from these gases in cylone 1, introduced into the riser pipe from the cyclone 3, precalcined in the gases coming from this cyclone and separated in cyclone 2. During this treatment the main part of the free water and the crystal water is removed. Then the precalcined material is introduced into the reaction chamber 4 and brought into intimate contact with fuel and oxygen containing gas. Rapid combustion takes place in a combustion zone having a small extent providing a very rapid rise in temperature of the alumina particles, initiating the exothermal recrystallization process in a very short time. Due to the exothermal reaction within the particles they are further heated leading to a very rapid recrystallation. During this process the aluminaparticles are suspended in the gaseous mixture of oxygen containing gas and combustion products, and carried out of the reaction chamber by this gaseous mixture and separated therefrom in cyclone 3. The recrystallized product containing the desired amount of α-alumina is cooled in cooler 5.

Figure 2 shows a preferred example of the apparatus. In this Figure , reference numbers 1 to 11 refer to the same features as reference numbers 1 to 11 in Figure 1. Figure 2 shows the electrostatic precipitator 14. Further the material exit pipe from the last cyclone is divided into two pipes 13 and 13' having valves 15 and 15' respectively. The preheated material coming from the first cyclone can thus be divided into two streams of which the first through pipe 13 and valve 15 is fed to the riser pipe from the cyclone 3 as explained above. The second stream is fed to a mixing and cooling chamber 5' in which it is mixed with the hot product separated from the hot gases leaving the reaction chamber 4. After mixing and cooling in chamber 5' the mixed product is fed to a cooling air pipe 12 suspended in the cooling air, and separated in cyclone 5, which can be the highest stage in a multi-stage cyclone cooler.

The invention will now be further described with reference to the following examples:

A calcination installation comprising a cylindrical reaction chamber of 600 mm inside diameter and 3800 mm height is heated by light fuel oil (nett calorific value: 10150 Kcal/kg) and supplied with air at a rate leading to a velocity of about 3.8 meter/second in the reaction chamber.

Wet Al_2O_3, $3H_2O$ (filter cake) with about 12% free moisture is preheated in the exit gases from the reaction chamber in a pre-heater as shown on Figure 1. During the preheating the free water is evaporated, yielding a dry Al_2O_3, $3H_2O$ with a loss of ignition about 34.9%, which is further heated in the preheater yielding a feed product to the reaction chamber essentially comprising Al_2O_3, and having a loss of ignition about 3-6% and a temperature about 400-450°C.

This feed product consisting of precalcined alumina is introduced at the bottom of the reaction chamber and brought into intimate contact with the fuel oil introduced below the feed material. The mixture of alumina and fuel oil is suspended in the combustion air, which is introduced at the centre of the bottom of the reaction chamber providing the initiation zone at the bottom of the reactor. The temperature in the reaction chamber is measured at three positions in the reaction chamber and a value is obtained which can be considered an average temperature in the reactor.

By varying the fuel feed rate and air supply the average temperature in the reaction chamber can be changed corresponding to more or less hard burning of the alumina, that is larger or smaller amounts of α-alumina.

The burned alumina is carried out from the reaction chamber as a suspension, separated from the hot gases and cooled.

After cooling, the α-alumina content and the loss of ignition are measured. Table 1 shows typical values of products obtained as described above.

Table 1

Example	*Average reactor temperature (°C)*	*Content of α-alumina(%)*	*Type of alumina*	*Gas retention time (seconds)*
1	1500	75	Floury	0.89
2	1420	56	Floury	0.88
3	1400	39	Intermediate	0.80
4	1335	17	Sandy	1.02
5	1260	9	Sandy	0.96

All these products showed a Loss of Ignition varying from 0.1 to 0.5%, and they were produced in quantities of about 200 kg per hour.

Tables 2 and 3 shows typical values of further products obtained as described above.

Table 2

Example	*Average reactor Temperature (°C)*	*Loss of Ignition (%)*	*BET Specific surface Area (m^2/g).*
6	1510	0.53	15.5
7	1435	0.61	31.4
8	1290	–	48.1

Example	*α-Alumina content in different fractions*				
	>74	63-74	44-63	<44	Total
6	75.2	75.7	76.2	79.0	77.6
7	40.5	43.7	45.6	50.5	47.4
8	16.7	14.5	14.5	13.6	14.5

X-ray diffractograms of the alumina samples showed the following distribution of minerals in the samples tabulated in Table 3.

Table 3

Example \ *Content (Qualitative)*	*Main*	*Large*	*Small*
6	α-Al_2O_3	-	γ-, δ-, θ-Al_2O_3
7	α-Al_2O_3	γ-, δ-, θ-Al_2O_3	-
8	γ-, δ-, θ-Al_2O_3	α-Al_2O_3	-

As indicated above the method according to the present invention allows manufacture of alumina with a broad range of properties e.g. corresponding to sandy, intermediate and floury types of alumina.

The alumina produced according to the present invention, is a highly suitable basic material for the electrolytic manufacture of aluminium.

The demands on the alumina can vary from factory to factory, but are typical in an α-alumina content on 10-20%; BET Specific Surface Area 40-60 m^2/g and Loss of Ignition <1%

CLAIMS

1. A method of producing anhydrous alumina from alumina trihydrate in which free and chemically bound water is at least partially removed in a precalcining zone wherein the alumina trihydrate is suspended in and by and separated from a stream of hot gases, whereafter the precalcined dehydrated alumina is recrystallized at least partially to α-alumina in a reaction chamber provided with means for feeding fuel and oxygen containing gas to a combustion zone in the chamber, in which the exothermal recrystallization is initiated by further heating the precalcined alumina by suspending the material in hot combustion gases; whereafter the at least partially recrystallized alumina is carried out in the reaction chamber suspended in the combustion gas stream, separated from the gas stream and subjected to rapid cooling in a cooling zone, characterized by providing a vigorous initiation of the recrystallization reaction by intimate mixing of precalcined alumina and fuel followed by suspension of this mixture in the oxygen containing gas fed to the combustion zone.

2. A method according to claim 1, characterized in that the oxygen containing gas is passed upwards through the centre of the bottom of the reaction chamber, that the intimate mixing of precalcined alumina and fuel is established by introducing precalcined alumina and fuel at the bottom of the reaction chamber in mutually intersecting directions, and that the at least partially recrystallized alumina and the exit gases from the combustion zone are carried out at the top of the reaction chamber by the gas stream.

3. A method according to claim 2, characterized in that the precalcined alumina is fed onto a downwardly and inwardly inclined annular bottom wall of the reaction chamber.

4. A method according to claim 2 or claim 3,

characterized in that the fuel is supplied at a lower position in the reaction chamber than the precalcined material.

5. A method according to claim 4, characterized in that the fuel is supplied upwards through a bottom wall of the reaction chamber.

6. A method according to one of claims 1 to 5, characterized in that the gas stream from the reaction chamber relieved of the suspended alumina is used as hot gas for drying and precalcining the material in the precalcining zone.

7. A method according to any one of claims 1 to 6, characterized in that fine dust is separated from the exit gas from the precalcining zone and that the fine dust is introduced into the suspension of material in the exit gases from the reaction chamber after the suspension has left the reaction chamber.

8. A method according to any one of claims 1 to 7, characterized in that the precalcining is carried out in a multi-stage cyclone preheater.

9. A method according to any one of claims 1 to 8, characterized in that the material separated from the gas stream coming from the reaction chamber is cooled by suspension in cooling air, separated from that air, and that used cooling air is introduced into the reaction chamber as oxygen containing gas.

10. A method according to claim 8, characterized in that the material coming from the uppermost cyclone is divided into two material streams, the first material stream being directed to the riser pipe to the second cyclone from the top, the second material stream and the material separated from the gas stream coming from the reaction chamber being suspended in cooling air, whereafter the material is separated from the air and subjected to further cooling and the air is introduced into the reaction chamber as oxygen containing gas.

11. A method according to claim 10, characterized in that the second material stream and the material separated from the gas stream coming from the reaction chamber are introduced into a mixing chamber and mixed before they are suspended in the cooling air.

12. A method according to claim 1, substantially as described with reference to the accompanying drawings.

13. Anhydrous alumina which has been produced by a method according to any one of the preceding claims.

14. Apparatus for producing anhydrous alumina by a method according to any one of claims 1 to 12, the apparatus comprising a multi-cyclone precalciner connected to a tubular reaction chamber having an upright axis provided with a central gas inlet in the bottom of the chamber and a central gas outlet in the top of the chamber leading to a particle/gas separator and ducts for introducing alumina from the precalciner and fuel into the chamber, and a cooler for the alumina separated in the particle/gas separator, characterized in that the reaction chamber is provided with a downwardly and inwardly inclined annular bottom wall, and that the ducts for introducing precalcined alumina and fuel are situated at the bottom of the chamber such that precalcined alumina and fuel enter into the chamber in intersecting paths.

15. Apparatus according to claim 14, characterized in that the fuel duct is situated below the duct for the precalcined material.

16. Apparatus according to claim 11 or claim 12, characterized in that the fuel duct is situated in the bottom wall.

17. Apparatus according to any one of claims 14 to 16, characterized in that it comprises an exit gas pipe from the precalciner provided with an electrostatic filter and means for introducing filter dust from the filter into the riser pipe from the reaction chamber.

18. Apparatus according to any one of claims 14 to 17, characterized in that the material outlet from the uppermost cyclone is provided with means for dividing the material stream into two material streams, the first material stream being directed via a duct to the riser pipe to the second cyclone from the top, and the second material stream and the material separated in the particle/gas separator being directed via ducts to a cooling air pipe in which the material is suspended whereby the outlet end of the air suspension pipe is connected to a separator having an outlet for the separated material and an outlet for air connected to the central gas inlet in the bottom of the reaction chamber.
the reaction chamber.

19. Apparatus according to claim 18, characterized by having a mixture chamber connected to the outlet end of the ducts for the second material stream and the material separated from the gas stream coming from the reaction chamber the mixing chamber having an outlet duct with an outlet in the cooling air pipe.

20. Apparatus according to claim 14, substantially as described with reference to Figure 1 or Figure 2 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1979.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

THIS PAGE BLANK (USPTO)